

Concerning the determination of the sensitivity of hot-wire anemothermometers in supersonic flows

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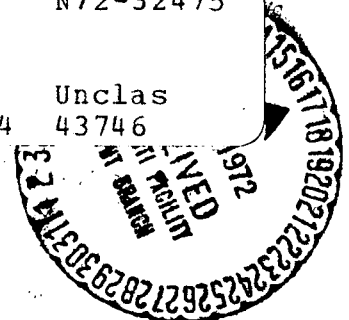
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Concerning the determination of the sensitivity of hot-wire anemothermometers in supersonic flows.*

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Abstract { Two methods are mentioned which are used to determine the sensitivity of hot-wire anemothermometers used to analyze the turbulence of supersonic flows. One method is imprecise with the lower Reynolds numbers, but the application is relatively easy; the other is precise, however, difficult to implement. New results from experiments allow the respective advantages of these two methods to be combined.

1. The sensitivity to longitudinal fluctuations $(\rho u)'$ of the amount of movement ρu , and T'_0 of the stopping temperature T_0 of a wire perpendicular to a supersonic flow of Mach $1.25 < M < 5$ are favorably determined with the aid of experimental methods which take into account the heat losses of the wire through the pins on which the wire is soldered [(4) to (6)].

R_w and T_w are the electric resistance and the temperature of

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the wire heated by a current of constant intensity I ; R_e and T_e are the limits of R_w and T_w when $I \rightarrow 0$; $\bar{\alpha}_w = (R_w - R_e)/R_e$ is the coefficient of superheating; Nu_0 is the Nusselt number corresponding to T_0 .

The problem is to determine

$$F = - \left(\frac{\partial \log R_w}{\partial \log \rho u} \right)_{T_0} \quad \text{and} \quad G = \left(\frac{\partial \log R_w}{\partial \log T_0} \right)_{\rho u}$$

which are assumed to be independent of M , such as when the lengthening $1/d \rightarrow \infty$ (2). F is akin to α'_w , G decreases if $\bar{\alpha}_w$ increases. The properties depend on the Reynolds' number $R_{d_0} = \rho u d / \mu_0$ corresponding to T_0 .

2. Two methods are considered.

2.1 The first (3) expresses F and G in a general form which is only then workable when the network of curves $Nu_0(\sqrt{R_{d_0}}, T_w/T_0 = Cte)$ is assimilable in a bundle of straight lines converging in one point $\sqrt{R_{d_0}^*}$ of the axis of abscissae; this condition is realized when R_{d_0} is greater than a R_{d_0}' limit whose determination is imprecise and which depends on the "end effects."

When $R_{d_0} < R_{d_0}'$, one commits an error difficult to estimate.

2.2. The second method (4) provides F and G by derivation from the network of curves yielding $R_w(\rho u)$ for $T_0 = Cte$ and $R_w(T_0)$ for $\bar{p}_0 = Cte$, \bar{p}_0 being the stopping pressure; the parameter is I .

2.3. When $\bar{\alpha}_w \rightarrow 0$, $F \rightarrow F_0$, the expressions of F_0 deduced from methods I and II are identical. The same is true for G_0 , the limit of G .

3. A synthesis of the two methods was researched to attempt to combine their advantages; the synthesis relied on several observations.

In view of the determination of F , we present below the tare of a platinum-covered tungsten wire; length, $l = 0.7$ mm; diameter, $d = 2.5$ μ ; $T_0 = 295$; $M = 2.3$.

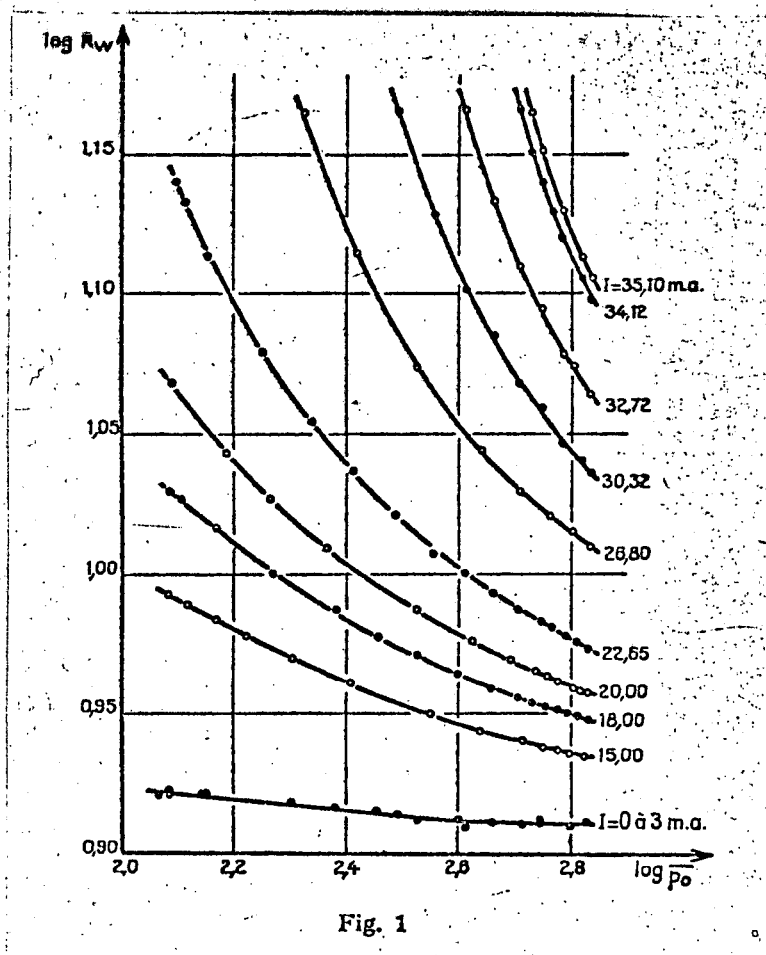


Fig. 1

- Figure 1 shows the network of curves $(\log R_w; \log \bar{p}_c)_{T_c}$;
- A series of experiments made for different values of R_{d_0} has shown that the curves $F(\bar{a}'_w)$ determined by methods I and II differ the less that R_{d_0} is higher, and become coincident when $R_{d_0} \geq 8$ which establishes $R'_{d_0} = 8$. Figure 2 provides an example of the results for $R_{d_0} = 4.3$, the two methods provided different values of F , especially with higher values of \bar{a}'_w ; for $R_{d_0} = 11.4$, the values

agree.

- It was verified that no matter what the length l/d , F_0 decreases when R_{d_0} increases and for all practical purposes cancels itself for $R_{d_0}'' = 2R_{d_0}'$. For $l/d \rightarrow \infty$, R_{d_0}' would be on the order of 20.

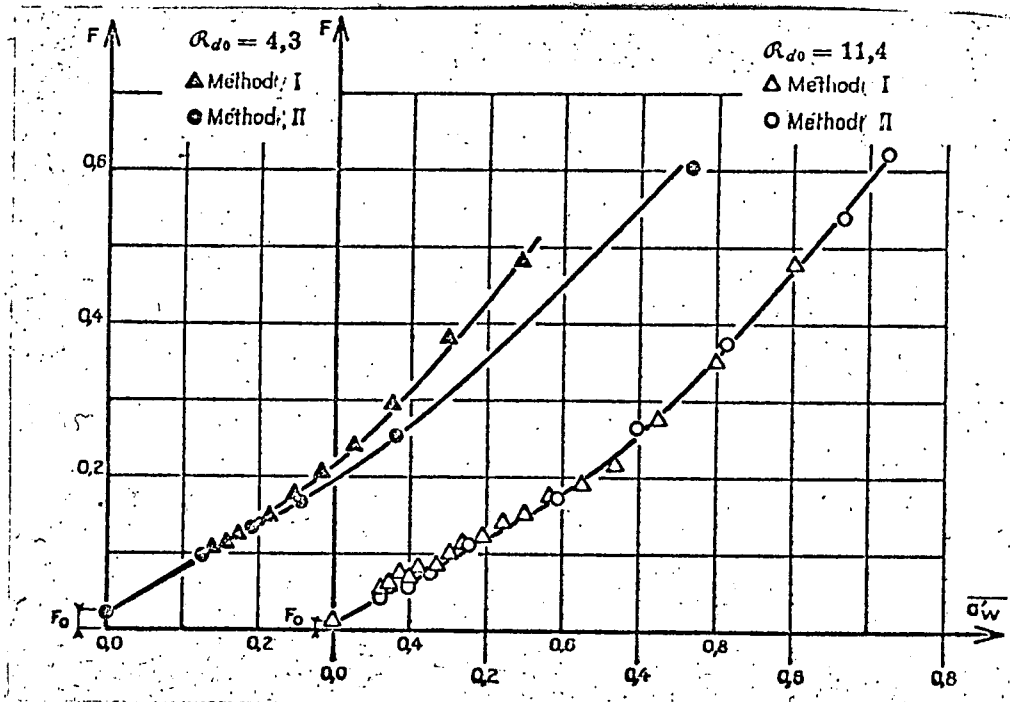


Fig. 2

- Figure 3 shows that F , determined by method II, depends little on R_{d_0} and by the intermediary of F_0 . In posing $F(\bar{a}'_w, 2R_{d_0}) = F_1(\bar{a}'_w)$, F can be represented by an expression such that

$$F(\bar{a}'_w, 2R_{d_0}) = F_1(\bar{a}'_w) + \frac{F_0(R_{d_0})}{1 + C\bar{a}'_w^2},$$

where C is a constant whose worth here is approximately 10.

- The experimental tare method reduces itself to: $F_1(\bar{a}'_w)$ is determined by method I (at a Reynolds' number of $R_{d_0} \simeq 2R_{d_0}'$); to which one adds the correction due to $F_0(R_{d_0})$.

The coefficient C can be determined by method I, noting that

its expression contains on the one hand terms which can be measured without any error specifically due to R_{de} , while on the other hand there is a term proportional to F which may be computed by the aforementioned relation.

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